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TECHNOLOGICAL PROCESSES OF URANIUM EXTRACTION

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Mining and processing of uranium raw materials are essential for the nuclear industry. In current time uranium is mined by in situ leaching. A leaching agent is pumped through the well, and a productive solution containing uranium comes to the surface. Due to low concentration of uranium in obtained solutions, a concentration stage is carried out for complete extraction.

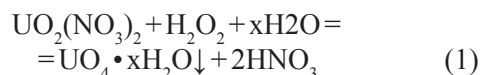
Nowadays, sorption is the main industrial method of concentrating uranium. Desorbates are precipitated, and then calcined to uranium oxide (U_3O_8). The resulting uranium concentrate should be easily filtered, dried, and should not contain significant impurities. The content of neutron-active impurities such as boron, cadmium, rare earth elements (REE), as well as iron, vanadium, silicon, etc. should be monitored especially carefully.

Hydrogen peroxide, ammonium or sodium hydroxides are commonly used as precipitants. Significant disadvantages of peroxide deposition are low filterability of sediments, the production of coarse-grained powders unsuitable for fluoridation and pressing in the manufacture of nuclear fuel elements cores [1]. In addition, U_3O_8 formed during calcination after peroxide deposition is almost chemically inert and does not meet the requirements of nuclear purity, as a result of which additional purification is necessary. Accordingly, a possibility of change over from direct deposition of uranium to extraction is considered. The advantages of the extraction method over the precipitation method are its selectivity, quickness of the process and the possibility of obtaining high separation factors.

The most common extraction refining of ura-

nium from nitric acid solutions with use of tributyl phosphate ($(C_4H_9)_3PO_4$) as an extractant. Thus, the desorption of uranium with ammonium nitrate allows using TBP or its synergetic mixtures with amines as an extractant [2].

As part of this work, uranium oxide was obtained in three different ways of sedimentation: peroxide, ammonium and extraction. Peroxide precipitation was carried out using a 30% H_2O_2 solution at pH ranging from 0.5 to 3.5. The reaction is described by the following equation:



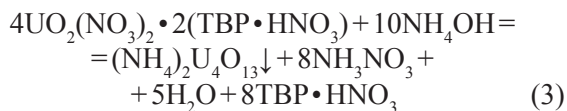
Boron and REE impurities are well separated, but in addition to uranium Fe, P, Al and V are deposited. That is unacceptable, as long as a large amount of impurities destroys hydrogen peroxide and interfere with the deposition of uranium.

A 25% NH_4OH solution was used for ammonium deposition:



Quantitative precipitation of uranium begins at pH=6–7, phosphorus, vanadium and partially REE are also precipitated.

During extraction precipitation, uranium was first extracted with 30% TBP solution in rubber solvent. At this stage, the majority of impurities are separated, because TBP mainly extracts nitrates, which are able to associate into molecules (nitrates U(VI), Pu(VI), and partly Zr and Hf). Solid phase reextraction, similar to the process of ammonium deposition, was carried out:



As a result, 3 samples of uranium oxide were obtained by calcination of the precipitates. The least amount of impurities was in U_3O_8 after extraction precipitation, most of all – after ammonium. Urani-

um peroxide is very difficult to filter, and increasing the temperature significantly reduces the yield of peroxide. Thus, the replacement of direct precipitation with extraction allows not only to obtain a cleaner product, but also eliminates several stages of the processing scheme, thereby reducing economic costs.

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MATHEMATICAL MODELING OF CHEMICAL TECHNOLOGY OF HYDROCARBONS PYROLYSIS

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This paper considers mathematical modeling of chemical technology of thermal process of hydrocarbons pyrolysis.

Thermal pyrolysis is the process of decomposition of hydrocarbons (HC), occurring in tube furnaces at high temperatures 700–900 °C with the addition of water vapor. The main commodity products are ethylene and propylene [1].

The aim of this work is to continue the development of a modeling system of chemical technology of thermal hydrocarbons pyrolysis.

Development of works on mathematical modeling of chemical technology of thermal pyrolysis process of various hydrocarbons is planned in two directions:

First, the development of models of other units or divisions of industrial production of pyrolysis and their addition to the previously developed [1–3] computer information modeling system of the main unit of the hydrocarbons pyrolysis process.

Secondly, the development of models for more modern and powerful pyrolysis furnaces, such as furnaces with coils of SRT-VI type.

The modeling system of chemical technology of thermal pyrolysis process of various hydrocarbon raw materials should include a mathematical description of all components of the industrial process plant: hydrocarbon pyrolysis unit, compression

of pyrolysis unit, unit of cracking gas cleaning from sulfur compounds and its drying, gas separation unit.

The main technological scheme is the pyrolysis unit, which includes a block of furnaces operating in parallel.

The modeling system of the main pyrolysis unit developed [1–3] as a computer information modeling system (IMS) is based on deterministic models. Deterministic mathematical models take into account (describe) the physical and chemical nature of the process and therefore are sensitive to changes in the component composition of raw materials and operating parameters.

IMS includes libraries of models of pyrolysis kinetics of gaseous raw materials (ethane-propane fractions, C4 fraction, broad fraction of light hydrocarbons) and liquid raw materials (wide gasoline fraction, refineries) as well as models of furnaces of SRT type.

The furnace model library consists of furnace models of SRT-I – SRT-IV types. Approbation of furnace models and conducted studies were performed for furnaces of SRT-I and SRT-II types.

The development of modern furnaces SRT («Short Residence Time» by «Lummus» company) goes to increasing the degree of branching. It is known that in October 2018 at the ethylene plant